

PATENT ABSTRACTS OF JAPAN

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(71)Applicant : SUMITOMO METAL IND LTD

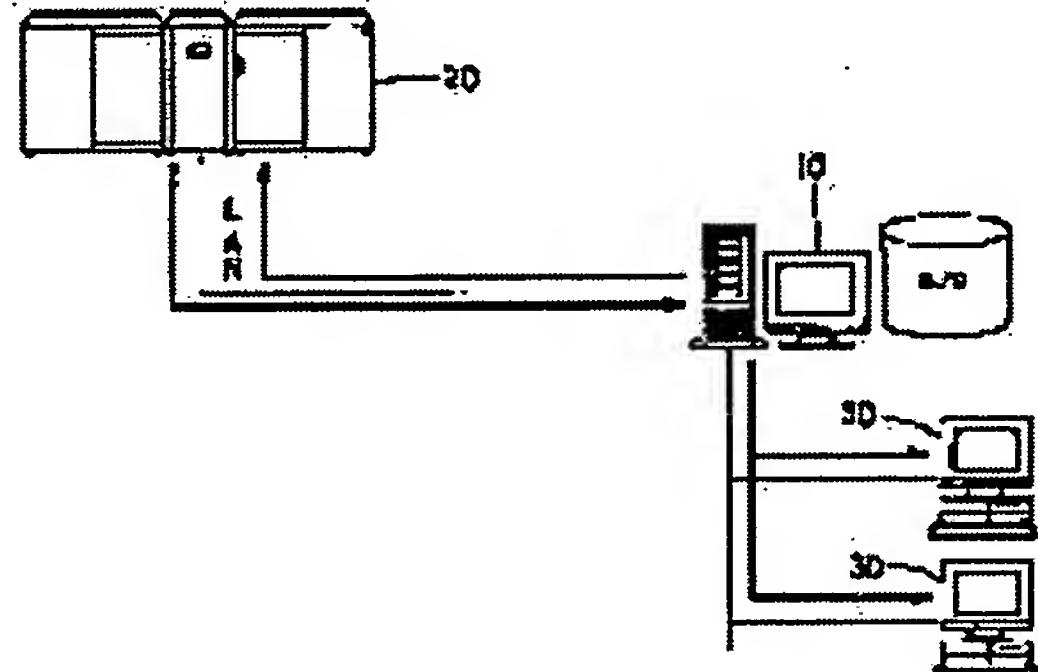
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MIMURA MASAKI

(54) CUTTING OF CRYSTAL

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a method for cutting a crystal, intended for reducing cutting frequency and avoiding the derivation of thin-walled products associated with the cutting operation, by estimating the oxygen concentration distribution in the axial direction of a single crystal grown by CZ process based on the relevant past results and then determining the positions to be cut at based on the oxygen concentration distribution thus estimated.



SOLUTION: This method for cutting a crystal comprises the following procedure: the past operational results in respective ovens are stored in a host computer 20; when the operational conditions for the respective ovens for producing a targeted item are inputted, a computer 10 receives the operational results corresponding to the respective ovens from the host computer 20 and stores them in a database; using the above operational results, oxygen concentration distribution characteristics are prepared; using these characteristics, the oxygen concentration distribution in the axial direction of a single crystal to be grown is estimated; the computer 10 determines a range within which the single crystal can be made into a successful product based on the quality specification (oxygen concentration distribution) of the product which has received orders and the estimated oxygen concentration range; while considering order volume, the product is assorted starting from the priority level; thereby the product can be exhaustively taken from the whole single crystal.

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CLAIMS

[Claim(s)]

[Claim 1] Crystal cutting process characterized by presuming oxygen density distribution of the shaft orientations of the single crystal raised from the past operation track record, and determining a cutting location based on the presumed oxygen density distribution while raising a single crystal by the CZ process.

[Claim 2] Crystal cutting process according to claim 1 characterized by determining a cutting location in order to extract two or more kinds of products with which oxygen density spec. differs from the raised single crystal.

[Claim 3] Crystal cutting process according to claim 1 or 2 characterized by determining a cutting location based on oxygen density distribution of the single crystal which grasps the oxygen density distribution property of a crystal orientation in two or more raising furnaces, and is predicted from the property.

[Claim 4] Crystal cutting process according to claim 3 characterized by updating the oxygen density distribution property of each raising furnace for every raising of the count of a unit using the observation data of oxygen density distribution of a single crystal.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the crystal cutting process used in order to extract a product from single crystals, such as silicon manufactured by the CZ process.

[0002]

[Description of the Prior Art] The silicon single crystal used as a material of a semiconductor device is mainly industrially manufactured by the CZ process. A CZ process is an approach of raising the single crystal of silicon under seed crystal, by pulling up seed crystal like common knowledge, soaking seed crystal in the raw material melt of the silicon held in quartz crucible, and making hard flow rotate seed crystal and quartz crucible.

[0003] By the way, as quality of a silicon single crystal, specific resistance and an oxygen density are important. For this reason, the request to these properties from a user side is what [severe] very fine and, and, for this reason, the class of product manufactured by the manufacturer side is very various. And in the manufacturer side, the product of the form (aim form) with which are satisfied of demand quality is industrially manufactured using two or more raising furnaces according to an order-received situation. This is in the fundamental mass-production situation of a single crystal.

[0004] However, it is a very difficult technique to manufacture economically the product of the quality which a user side requires. because, many parts with which there are few parts which fulfill demand quality in one raised single crystal, and they do not fill the demand quality process as a loss (few dissolution raw materials of economic value) -- **** -- it is because the yield in product extraction is very low.

[0005] That is, in manufacture of the silicon single crystal using a CZ process, as shown in drawing 1 (a) or drawing 1 (b), the specific resistance of the raised single crystal pulls up, and it changes with the segregations of the doping element accompanying advance of raising in shaft orientations. Moreover, the oxygen density of a single crystal is also pulled up and it changes with reduction of the amount of melt accompanying advance of raising etc. in shaft orientations. For these reasons, there are very few parts (part of an aim form) with which it is satisfied of demand quality about both specific resistance and an oxygen density, and they are usually just over or below 50%.

[0006] It considers extracting two or more kinds of products with which demand quality differs from one single crystal raised in order to solve this problem. That is, the demand quality of a product distributes one single crystal to two or more kinds of products using various things. And as an applicant was the following, he was performing this distribution.

[0007] As shown in drawing 5 , cutting removal of the defect-of-shape section of the both ends of the raised single crystal 40 is carried out. the surviving configuration area free from defect -- the blocks 41 and 42 of predetermined die length (for example, 200mm) -- division-into-equal-parts cutting is carried out at .. An oxygen density is surveyed in each cutting location, and it asks for the oxygen density of the both-ends side of each block.

[0008] Now, in blocks 41 and 42, the oxygen density of a both-ends side aims, the oxygen spec. of a form is satisfied, and only the oxygen density of one end face aims, it is satisfied with block 43 of the oxygen spec. of a form, the oxygen density of an other-end side aims, and it is assumed that it separated from the oxygen spec. of a form. In such a case, blocks 41 and 42 are extracted as they are as an aim form. About block 43, block 43 is re-cut in the location which returned from the other-end side to the end side. This re-cutting is called cut return and that cutting margin L is determined based on the rate of a blank from the demand spec. of an oxygen density. That is, when the rate of a blank is large, it returns greatly, and when the rate of a blank is small, it returns small.

[0009] After cut return finishes, an oxygen density is surveyed again in the cutting location. When an actual measurement satisfies demand spec., body section 43a is aimed at and it extracts as a form. When an actual measurement does not satisfy demand spec., cut return is again performed to body section 43a. Thus, it aims from block 43 and a form is extracted. thin part 43b derived in connection with cut return -- other blocks 44 -- it turns to other forms in .. Cut return is performed suitably also here.

[0010]

[Problem(s) to be Solved by the Invention] According to such a product extracting method, when the product of two or more article kind is once extracted from the single crystal of one ** and it extracts only an aim form, the yield improves. However, in order to cut repeatedly to one single crystal, it is not only non-efficiency, but consumption of a cutting cutting edge is intense and cutter cost increases. In addition, in connection with cut return, the thin block of thickness arises so much. Although cutting is presented as a block which was made to stick two or more sheets mutually, and had sufficient thickness since these thin blocks cannot be cut to a wafer in many cases if they remain as they are, trouble starts the lamination.

[0011] The purpose of this invention is to offer the crystal cutting process which can reduce sharply the count of cutting in the case of product extraction, doubles, and can avoid a descendant of the thin article accompanying cutting.

[0012]

[Means for Solving the Problem] By the way, although two or more raising furnaces are used in the mass production of the single crystal by the CZ process in order to manufacture the product of the same form as mentioned above, oxygen density distribution especially becomes quality distribution of the shaft orientations of the single crystal raised at each furnace, and a greatly different thing, as shown in drawing 1 (a) and (b). Aside from the cause, although degradation of components and a furnace body property make a mistake in this being small and the deviation of an instrument etc. is the cause, even if it is going to pull up the product of the same property at each furnace, oxygen density distribution of the shaft orientations of the single crystal which can be pulled up becomes a greatly different thing, and, as for the oxygen density distribution, moreover, even the same furnace changes for every raising. For this reason, that oxygen density was actually measured by cutting as it was made impossible to presume oxygen density distribution of a single crystal correctly, therefore having been mentioned above in the product extraction from a single crystal.

[0013] However, when change at dispersion and the same furnace between the furnaces of the oxygen density distribution was investigated in the detail and the operation data of the past in each furnace were used, it becomes clear that oxygen density distribution of a single crystal can be presumed in precision with high extent which the oxygen density distribution property of each furnace becomes clear, consequently can be utilized for product distribution of a single crystal, and it came to complete this invention.

[0014] The single crystal cutting process of this invention makes it the focus on a configuration to presume oxygen density distribution of the shaft orientations of the single crystal raised from the past operation track record, and to determine a cutting location based on the presumed oxygen density distribution while raising a single crystal by the CZ process.

[0015] In the crystal cutting process of this invention, it is desirable to determine a cutting location so that two or more kinds of products with which oxygen density spec. differs from the raised single crystal may be extracted.

[0016] Moreover, in two or more raising furnaces, the oxygen density distribution property of a crystal orientation is grasped, and it is desirable to determine a cutting location based on oxygen density distribution of the single crystal predicted from the property.

[0017] In that case, it is desirable to update the oxygen density distribution property of each raising furnace for every raising of the count of a unit using the observation data of oxygen density distribution of a single crystal.

[0018]

[Embodiment of the Invention] The operation gestalt of this invention is explained based on a drawing below.

[0019] The crystal cutting process concerning the operation gestalt of this invention is used for efficient product extraction from the production control of a single crystal, and the single crystal more specifically raised at two or more raising furnaces. This production control is performed by computer 10, as shown in drawing 2. Finally the cutting location of a single crystal is directed by connecting the computer 10 with the host computer 20, delivering and receiving information between host computers 20, and processing drawing 3. the directions information -- two or more processing terminals 30 and 30 -- it is transmitted to ..

[0020] As information accepted from a host computer 20, there are an order-received situation, a product mechanism loan situation, a quality track record, operation data, product specification, etc. Moreover, as information transmitted to a host computer 20, there are single crystal cutting positional information, quality sample sampling information, mortgage directions information, etc.

[0021] Moreover, since various information required for the operation accepted from the host computer 20, the information generated within the computers 10, such as oxygen density distribution, operation processing track record data, etc. are stored, the computer 10 is equipped with the database.

[0022] A manager inputs serially into a computer 10 the quality specification, the amount, and the time for delivery of choice of the product which received the order. In operation, the highest form of priority is decided from a current order-received situation, and two or more raising furnaces perform crystal training in order to aim at this and to fill the amount of orders received of the form as a form. And a manager inputs the operating condition in each furnace for manufacturing the aim form into a computer 10, and directs distribution of a product. If it does so, a computer 10 will take out required information from a host computer 20, and will perform the program of 3 shown in drawing 3, i.e., priority data generation, oxygen density table generation, and a crystal production system.

[0023] In priority data generation, priority is determined from the time for delivery of choice of a product, the difficulty of training, etc. The determined priority is stored in the database of a computer 10.

[0024] In oxygen density table creation, oxygen density distribution is presumed as internal quality of the single crystal raised at each furnace. This process is explained below at a detail. In addition, although specific resistance and an oxygen density are important as internal quality of a product, explanation with management detailed only about the most difficult oxygen density of explanation for convenience is given.

[0025] The operation track records (an operating condition, oxygen density distribution, etc.) of the past in each furnace are stored in the host computer 20. If the operating condition of each furnace for manufacturing an aim form is inputted, for every furnace, a computer 10 accepts the operation track record corresponding to an operating condition from a host computer 20, and stores it in a database. Subsequently, oxygen density distribution of the shaft orientations of the single crystal raised is presumed using the oxygen density distribution property (table for oxygen density distribution presumption) of each furnace which created and created the oxygen density distribution property (table for oxygen density distribution presumption) using the operation track record.

[0026] It pulls up with quality track record data, and, specifically, the middle data which edited the oxygen spec. for ten batches, an oxygen track record, specification part article size, and a charge according to - oxygen spec. classified by furnace, respectively are generated from track record data. From middle data, the average value of oxygen track record data is taken according to - oxygen spec. classified by furnace, and it arranges and replaces with the shaft orientations of a single crystal, and registers as table data. The registered oxygen density table is employed and oxygen density distribution is presumed for every mm. An example of the created oxygen density table is shown in Table 1, and the oxygen density distribution presumed from the table is shown in drawing 4 (a).

[0027]

[Table 1]

L値	O _i 値	Min値	Max値
0	16.20	15.90	16.40
30	15.13	15.00	15.30
60	15.00	14.90	15.10
100	14.80	14.70	15.00
250	14.05	13.90	14.20
300	13.95	13.90	14.00
350	13.50	13.40	13.60
400	13.43	13.30	13.60
500	13.30	13.20	13.50
550	13.90	13.80	14.00
600	14.00	13.90	14.20
650	13.90	13.80	14.00
750	13.90	13.80	14.00
800	13.95	13.90	14.00
850	13.60	13.40	13.80
950	13.40	13.30	13.50
1000	13.30	13.20	13.40
1100	13.10	13.00	13.20
1150	13.00	12.90	13.10
1200	12.90	12.70	13.10

[0028] In a crystal production system, distribution of a product is performed using the priority determined as the presumed internal quality distribution.

[0029] That is, if the quality specification of the product memorized by the computer 10 is made into Table 2 and presumed oxygen density distribution is now made into drawing 4 (a), distribution will be performed as follows.

[0030]

[Table 2]

優先順位	品種	酸素濃度 (atoms/cc)	製品化可能位置 (mm)	最終振分位置 (mm)
1	A	13.2~15.0	150~ 500	150~ 500
2	a	14.0~16.5	0~ 250	0~ 150
3	b	13.9~14.2	600~ 800	600~ 800
4	c	12.7~13.5	900~1200	900~1200
5	d	13.0~14.0	800~1150	800~ 900
6	e	12.7~15.0	50~1200	500~ 600

[0031] Form A is the main form (aim form) which had the predetermined oxygen density specified, and is the highest thing of a priority. Forms a, b, c, and d -- it is the subform with which ... had the predetermined oxygen density specified, respectively, and a priority is small in order compared with the main form A.

[0032] In distribution of a product, first, a computer 10 determines the range which can produce commercially in a single crystal from the oxygen density range presumed to be the quality specification (oxygen density distribution) of the product which received the order, as shown in drawing 4 (b). It can extract near the top of a single crystal, being able to cover [which is an aim form / A] it over pars intermedia. The oxygen density of priority is high and it can extract the form a of the 2nd place from the top section of a single crystal. Being able to extract priority of an oxygen density being able to be comparatively low and being able to cover the 3rd and the forms b and d of the 5th place near the bottom from the pars intermedia of a single crystal, especially the form b is a form with a severe quality specification with the narrow range of an oxygen density. The oxygen density of priority is the lowest and it can extract the form c of the 4th place near the bottom section of a single crystal. priority -- the form e of the 6th place -- the range of an oxygen density -- large -- a single crystal -- almost -- the extraction from an overall length -- being possible .

[0033] If the possible range of commercial production is determined, final distribution of a product will be performed from priority, taking the amount of orders received into consideration, as shown in drawing 4 (c-1). That is, the form A which is an aim form is assigned to all of extractable locations. Priority avoids a duplication part with Form A, and assigns the form a of the 2nd place to the top section of a single crystal. Priority assigns the form b of the 3rd place with the priority to the remaining part. Continuously, priority assigns preferentially the 4th and the forms c, d, and e of the 5 or 6th place to the remaining part in order.

[0034] When there is much amount of orders received of Form e, as shown in drawing 4 (c-2), some forms c are transposed to Form e. Moreover, when there is much amount of orders received of Form d, as shown in drawing 4 (c-3), some forms c are transposed to Form d.

[0035] The yield when being extracted in this way, without the whole single crystal product [from] leaving according to an order-received situation, and extracting a product from a single crystal improves by leaps and bounds, and the excess and deficiency to an order received are not produced, either.

[0036] In addition, it is extracted, without a single crystal to a product leaving almost, without producing excess and deficiency [as opposed to / by performing synthetic distribution to the single crystal which can extract at the furnace of others / product / unextractable at a certain furnace although Form A is aimed at at each furnace and a single crystal is raised, since those oxygen density distribution is not the same / and is raised at each furnace / an order received in actual operation].

[0037] If a single crystal is raised at each furnace, a single crystal will be cut according to the determined distribution. Moreover, the oxygen density of a single crystal is measured in a cutting location, and the data is fed back to a computer 10.

[0038] Strictly, whenever the oxygen density distribution property (table for oxygen density distribution presumption) in each furnace raises one single crystal, it changes. For this reason, the newest observation data are fed back to a computer 10. A computer 10 always creates an oxygen density distribution property (table for oxygen density distribution presumption) using the data (for example, the newest to ten data) of the latest predetermined number. Thereby, oxygen density distribution of the single crystal raised at each furnace is presumed with high precision.

[0039]

[Effect of the Invention] As explained above the crystal cutting process of this invention While raising a single crystal by the CZ process, presume quality distribution of the shaft orientations of the single crystal raised from the past operation track record, and by determining the cutting location of a single crystal based on the presumed quality distribution Since two or more kinds of products with which the demand spec. of an oxygen density differs can be direct cut down the neither more nor less in case a product is extracted from a single crystal, isometric cutting for surveying the oxygen density of a single crystal is not needed, and cut return is not needed, either. Therefore, the count of cutting in the case of product extraction can be reduced sharply, and the cutter cost in the cutting can be reduced sharply. Moreover, since a descendant of the thin article accompanying cutting is avoidable, the man day at the time of cutting a single crystal to a wafer can be reduced.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the graph showing typically specific resistance distribution and oxygen density distribution of a single crystal.

[Drawing 2] It is the equipment configuration Fig. of the production control system using the crystal cutting process concerning the operation gestalt of this invention.

[Drawing 3] It is the flow chart which shows the software of this production control system.

[Drawing 4] It is the conceptual diagram of the crystal cutting process in this production control system.

[Drawing 5] It is the conceptual diagram of the conventional crystal cutting process.

[Description of Notations]

10 Computer

20 Host Computer

30 Information Terminal

40 Single Crystal

41 and 42 .. Block

[Translation done.]

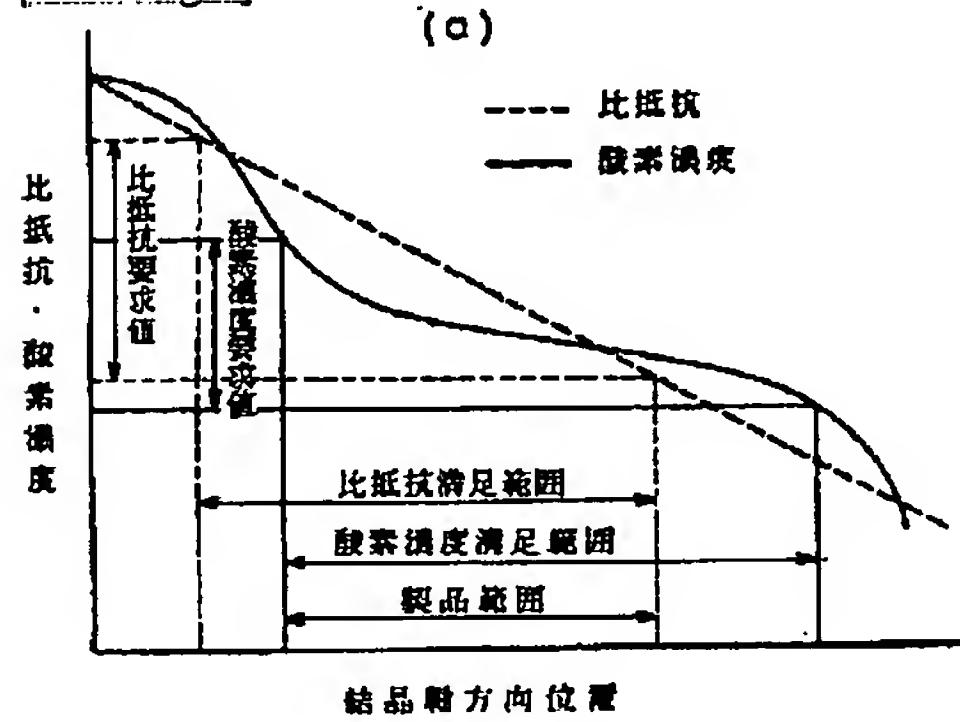
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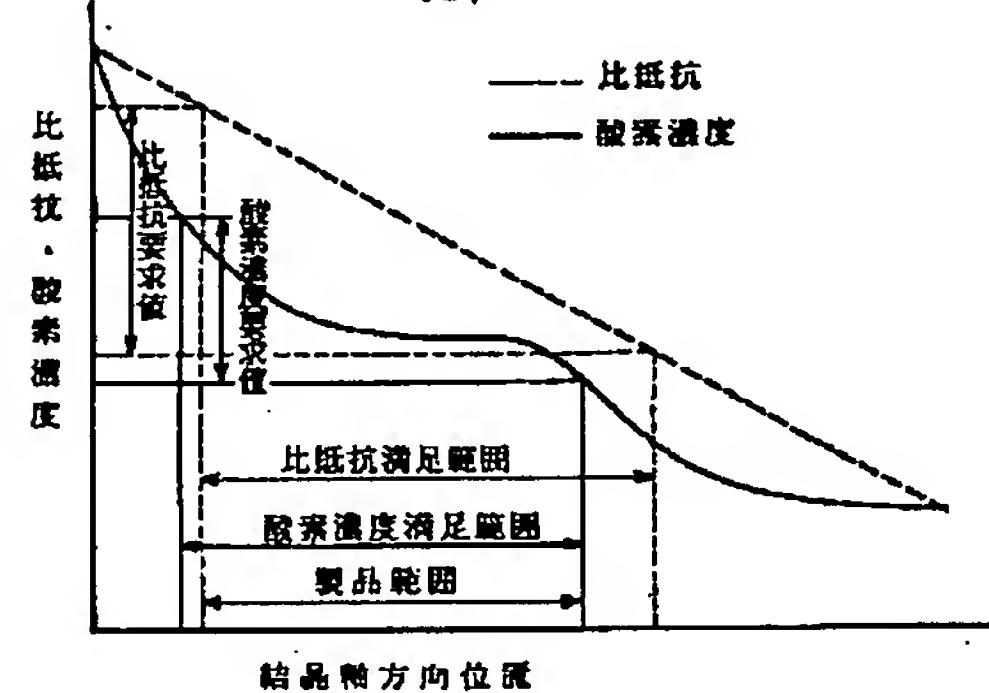
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DRAWINGS

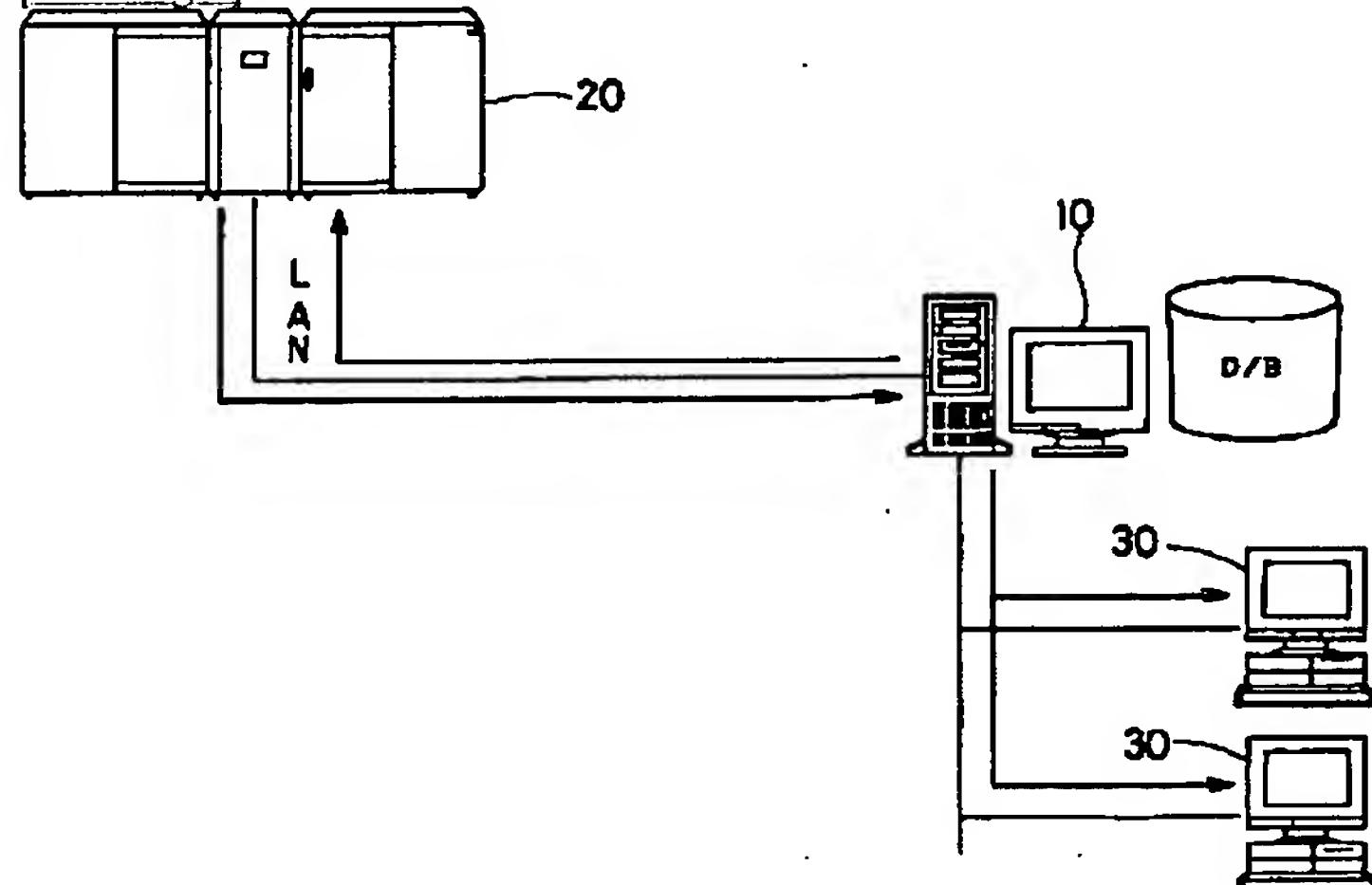
[Drawing 1]



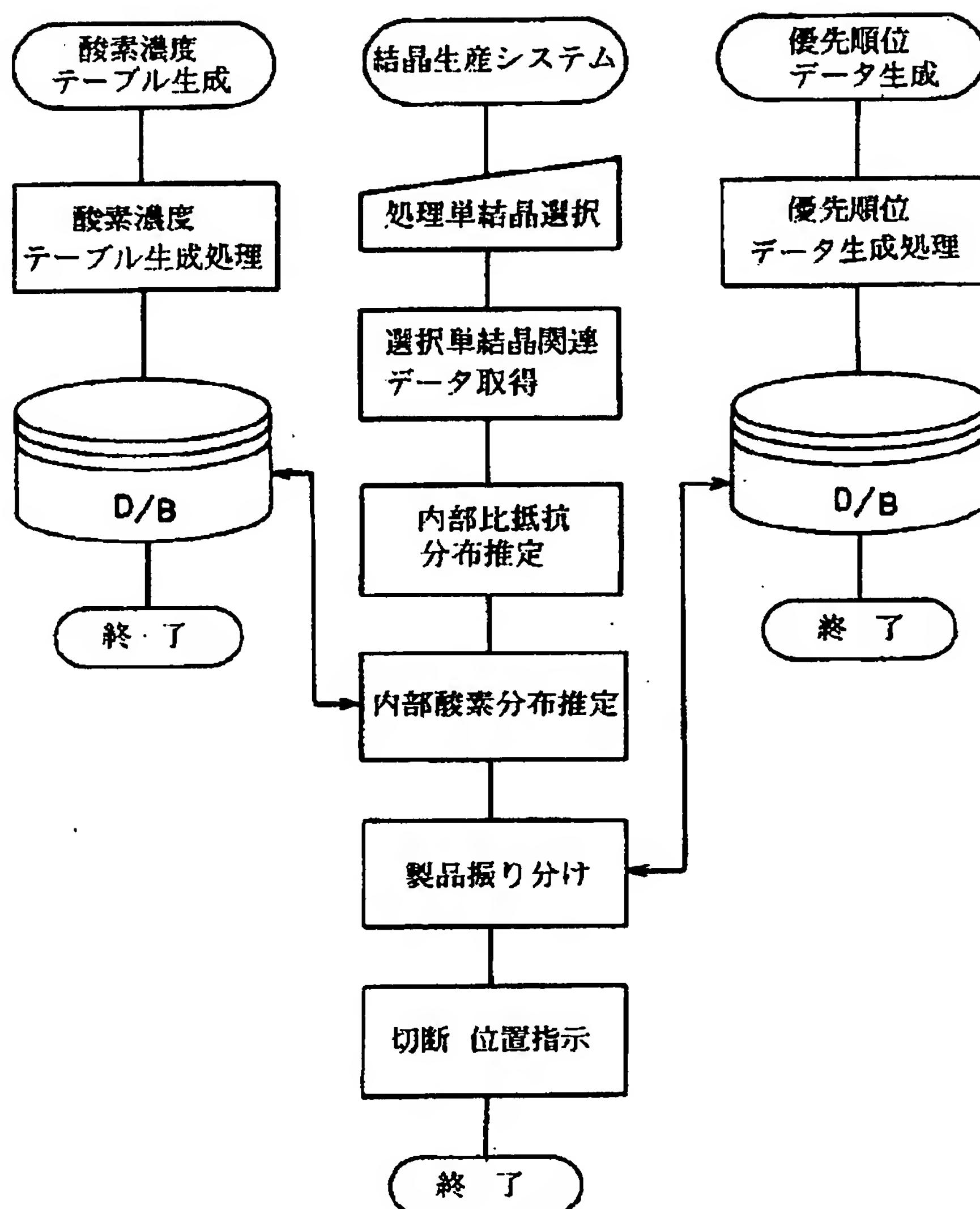
(b)



[Drawing 2]

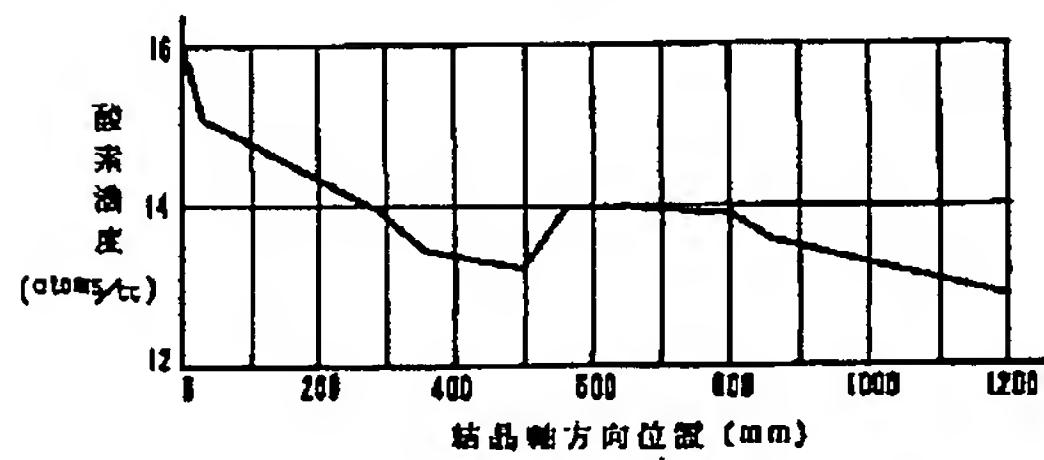


[Drawing 3]

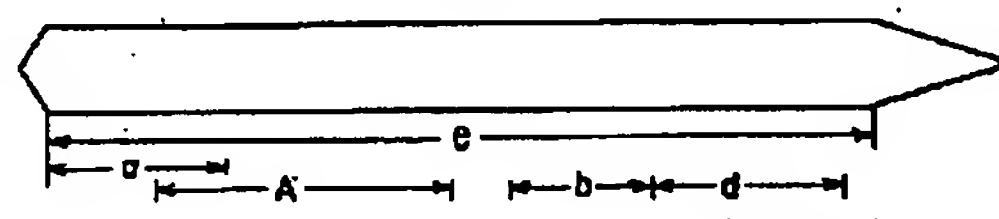


[Drawing 4]

(a)



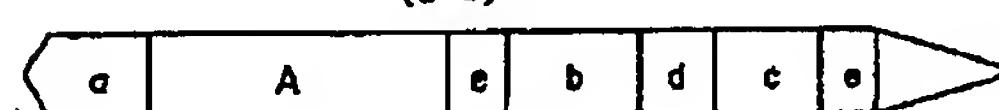
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(c-1)



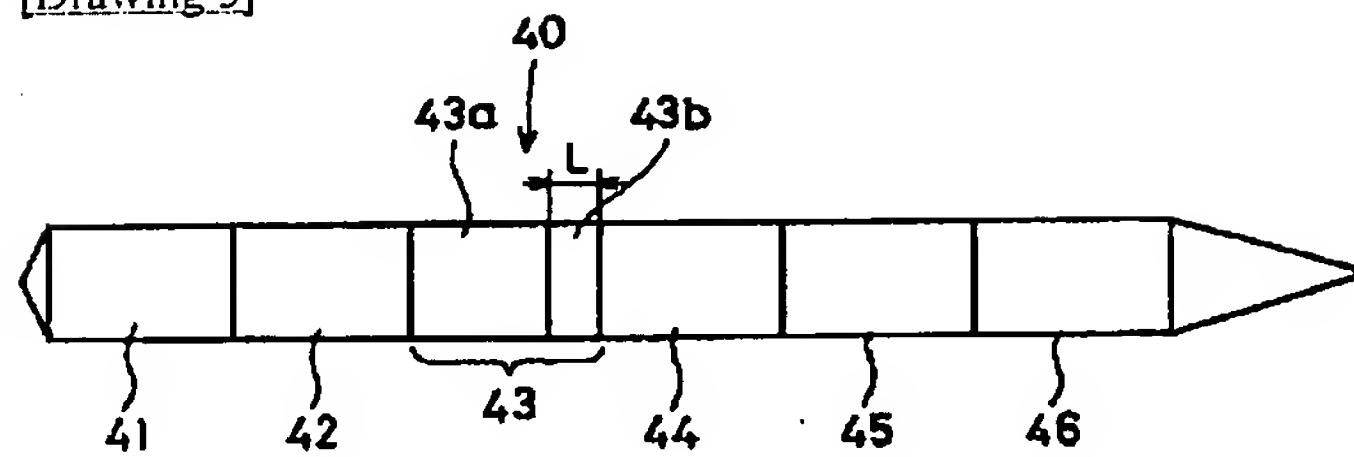
(c-2)



(c-3)



[Drawing 5]



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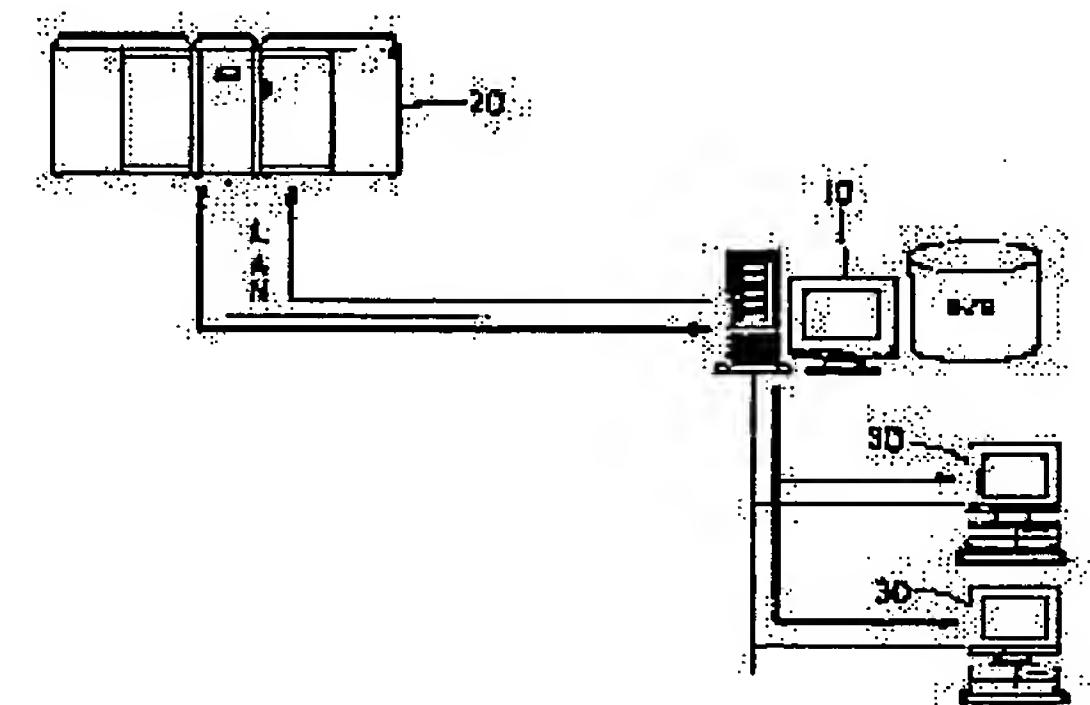
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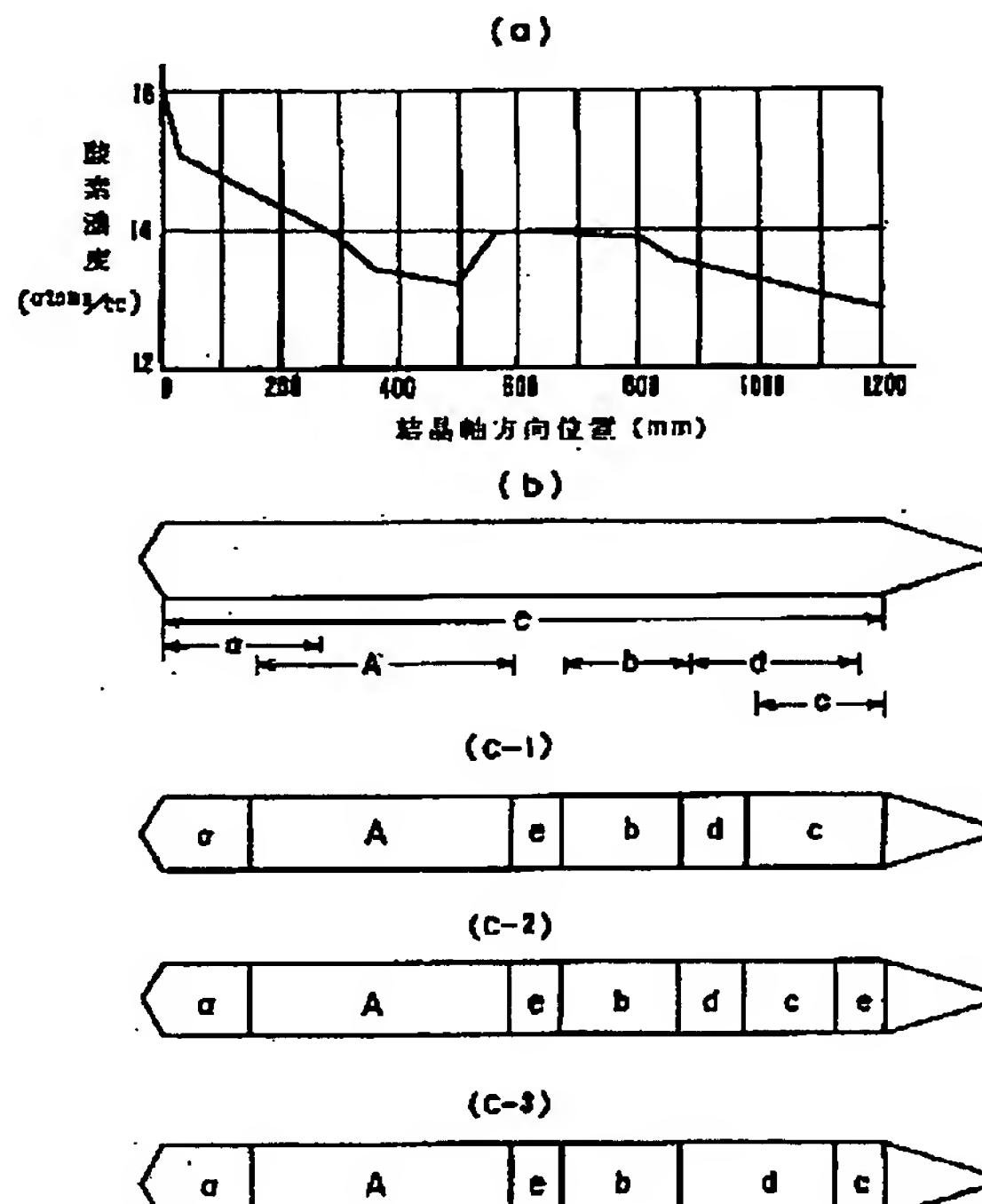
(74)代理人 弁理士 押田 良久 (外2名)

(54)【発明の名称】 結晶切断方法

(57)【要約】

【課題】 CZ法により育成される単結晶から製品を採取する際の切断回数を少なくし、刃物コストを低減する。切断に伴って薄厚品が派生するのを回避し、単結晶をウェーハに切断する際の工数を低減する。

【解決手段】 複数の引き上げ炉で単結晶の育成を行う。各炉で育成される単結晶の軸方向の酸素濃度分布を、過去の操業実績から推定する。推定された酸素濃度分布に基づき、酸素濃度スペックが異なる複数種類の製品が採取されるように、切断位置を決定する。



【特許請求の範囲】

【請求項1】 CZ法により単結晶を育成すると共に、育成される単結晶の軸方向の酸素濃度分布を過去の操業実績から推定し、推定された酸素濃度分布に基づいて切断位置を決定することを特徴とする結晶切断方法。

【請求項2】 育成された単結晶から酸素濃度スペックが異なる複数種類の製品を採取するべく、切断位置を決定することを特徴とする請求項1に記載の結晶切断方法。

【請求項3】 複数の引き上げ炉において結晶軸方向の酸素濃度分布特性を把握しておき、その特性から予測される単結晶の酸素濃度分布に基づいて切断位置を決定することを特徴とする請求項1又は2に記載の結晶切断方法。

【請求項4】 単結晶の酸素濃度分布の実測データを用いて、単位回数の引き上げごとに各引き上げ炉の酸素濃度分布特性を更新することを特徴とする請求項3に記載の結晶切断方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】 本発明は、CZ法により製造されるシリコン等の単結晶から製品を採取するために用いられる結晶切断方法に関する。

【0002】

【従来の技術】 半導体デバイスの素材として使用されるシリコン単結晶は、工業的には主にCZ法により製造される。CZ法とは、周知の如く、石英坩堝内に収容されたシリコンの原料融液に種結晶を漬け、種結晶及び石英坩堝を逆方向に回転させながら種結晶を引き上げることにより、種結晶の下にシリコンの単結晶を育成する方法である。

【0003】 ところで、シリコン単結晶の品質としては、比抵抗及び酸素濃度が重要である。このため、ユーザー側からのこれら特性に対する要望は非常に細かく且つ厳しいものになっており、このため、メーカー側で製造する製品の種類は非常に多岐に及んでいる。そして、メーカー側では、受注状況に応じ、要求品質を満足する品種（狙い品種）の製品を、複数の引き上げ炉を使用して工業的に製造している。これが単結晶の基本的な量産状況である。

【0004】 しかしながら、ユーザー側が要求する品質の製品を経済的に製造することは、非常に困難な技術である。なぜなら、育成された1本の単結晶のなかで要求品質を満たす部分が少なく、その要求品質を満たさない多くの部分がロス（経済価値の少ない溶解原料）として処理されたため、製品採取における歩留りが非常に低いからである。

【0005】 すなわち、CZ法を用いたシリコン単結晶の製造では、図1（a）又は図1（b）に示すように、引き上げの進行に伴うドーピング元素の偏析により、育

成された単結晶の比抵抗が引き上げ軸方向において変化する。また、引き上げの進行に伴う融液量の減少等により、単結晶の酸素濃度も引き上げ軸方向において変化する。これらのため、比抵抗及び酸素濃度の両方について要求品質を満足する部分（狙い品種の部分）は非常に少なく、通常は50%前後である。

【0006】 この問題を解決するために、例えば育成された1本の単結晶から、要求品質が異なる複数種類の製品を採取することが考えられている。即ち、製品の要求品質が多種多様なことを利用して、1本の単結晶を複数種類の製品に振り分けるのである。そして、この振り分けを、出願人は以下のようにして行っていた。

【0007】 図5に示すように、育成された単結晶40の両端の形状不良部を切断除去する。残った形状健全部を所定長さ（例えば200mm）のブロック41, 42・・に等分切断する。各切断位置で酸素濃度を実測し、各ブロックの両端面の酸素濃度を求める。

【0008】 今、ブロック41, 42では両端面の酸素濃度が狙い品種の酸素スペックを満足し、ブロック43では一方の端面の酸素濃度のみが狙い品種の酸素スペックを満足し、他方の端面の酸素濃度が狙い品種の酸素スペックを外れたと仮定する。そうした場合、ブロック41, 42は狙い品種としてそのまま採取される。ブロック43については、他方の端面から一端側へ戻った位置でブロック43を再切断する。この再切断は切り戻しと呼ばれ、その切断代しは酸素濃度の要求スペックからの外れ率に基づいて決定される。つまり、外れ率が大きい場合は大きく切り戻し、外れ率が小さい場合は小さく切り戻すのである。

【0009】 切り戻しが終わると、その切断位置で再度酸素濃度を実測する。実測値が要求スペックを満足した場合は、本体部43aを狙い品種として採取する。実測値が要求スペックを満足しない場合は、本体部43aに対して再び切り戻しを行う。このようにしてブロック43から狙い品種を採取する。切り戻しに伴って派生する薄厚部43bは、他のブロック44・・と共に他の品種に回す。ここでも適宜切り戻しを行う。

【0010】

【発明が解決しようとする課題】 このような製品採取法によると、一応は1本の単結晶から複数品種の製品が採取され、狙い品種のみを採取する場合に比べると歩留りが向上する。しかしながら、1本の単結晶に対して繰り返し切断を行うために、非能率であるだけでなく、切断刃の損耗が激しく、刃物コストが増大する。加えて、切り戻しに伴って厚みの薄いブロックが多量に生じる。これらの薄厚ブロックは、そのままではウエーハに切断できないことが多いので、複数枚を貼り合わせ十分な厚みを持ったブロックとして切断に供せられるが、その貼り合わせに手数がかかる。

【0011】 本発明の目的は、製品採取の際の切断回数

を大幅に低減でき、合わせて切断に伴う薄厚品の派生を回避できる結晶切断方法を提供することにある。

【0012】

【課題を解決するための手段】ところで、CZ法による単結晶の量産では、前述したように、同一品種の製品を製造するために複数の引き上げ炉を使用するが、各炉で育成された単結晶の軸方向の品質分布、とりわけ酸素濃度分布は、図1 (a) (b) に示すように、大きく異なるものとなる。これは部品の劣化、炉体特性の僅かな違い、計器の狂いなどが原因であるが、その原因はともかく、各炉で同一特性の製品を引き上げようとしても、引き上げられる単結晶の軸方向の酸素濃度分布は大きく異なるものとなり、しかも、同一炉でさえ引き上げごとにその酸素濃度分布は変化する。このため、単結晶の酸素濃度分布を正確に推定することは不可能とされ、従って、単結晶からの製品採取では、前述した通り切断によってその酸素濃度が実際に測定されていた。

【0013】しかし、その酸素濃度分布の炉間のばらつきや同一炉での変化を詳細に調査したところ、各炉での過去の操業データを使用すれば、各炉の酸素濃度分布特性が明らかとなり、その結果、単結晶の製品振り分けに活用できる程度の高い精度で単結晶の酸素濃度分布を推定できることが判明し、本発明を完成させるに至った。

【0014】本発明の単結晶切断方法は、CZ法により単結晶を育成すると共に、育成される単結晶の軸方向の酸素濃度分布を過去の操業実績から推定し、推定された酸素濃度分布に基づいて切断位置を決定することを構成上の特徴点とする。

【0015】本発明の結晶切断方法においては、育成された単結晶から酸素濃度スペックが異なる複数種類の製品が採取されるように、切断位置を決定することが好ましい。

【0016】また、複数の引き上げ炉において結晶軸方向の酸素濃度分布特性を把握しておき、その特性から予測される単結晶の酸素濃度分布に基づいて切断位置を決定することが好ましい。

【0017】その場合、単結晶の酸素濃度分布の実測データを用いて、単位回数の引き上げごとに各引き上げ炉の酸素濃度分布特性を更新することが好ましい。

【0018】

【発明の実施の形態】以下に本発明の実施形態を図面に基づいて説明する。

【0019】本発明の実施形態に係る結晶切断方法は、単結晶の生産管理、より具体的には、複数の引き上げ炉で育成される単結晶からの効率的な製品採取に用いられる。この生産管理は、図2に示すように、コンピュータ10により実行される。コンピュータ10はホストコンピュータ20と接続されており、ホストコンピュータ20との間で情報の授受を行い、図3の処理を行うことにより、最終的に単結晶の切断位置を指示する。その指示

情報は、複数の処理端末30, 30...に伝送される。

【0020】ホストコンピュータ20から受け入れる情報としては、受注状況、製品仕掛け状況、品質実績、操業データ、製品仕様等がある。また、ホストコンピュータ20へ転送する情報としては、単結晶切断位置情報、品質サンプル抜き取り情報、引き当指示情報等がある。

【0021】また、ホストコンピュータ20から受け入れた操業に必要な各種情報や、酸素濃度分布等のコンピュータ10内で生成した情報、操業処理実績データ等を格納するために、コンピュータ10はデータベースを備えている。

【0022】管理者は、受注した製品の品質仕様、量及び希望納期をコンピュータ10に逐次入力する。操業では、現在の受注状況から優先順位の最も高い品種を決め、これを狙い品種として、その品種の受注量を満たすべく複数の引き上げ炉で結晶育成を行う。そして管理者は、その狙い品種を製造するための各炉における操業条件をコンピュータ10に入力し、製品の振り分けを指示する。そうすると、コンピュータ10は、ホストコンピュータ20から必要な情報を取り出し、図3に示された3のプログラム、即ち優先順位データ生成、酸素濃度テーブル生成及び結晶生産システムを実行する。

【0023】優先順位データ生成では、製品の希望納期及び育成の難易度等から優先順位が決定される。決定された優先順位はコンピュータ10のデータベースに格納される。

【0024】酸素濃度テーブル作成では、各炉で育成される単結晶の内部品質として酸素濃度分布が推定される。以下にこの工程を詳細に説明する。なお、製品の内部品質としては比抵抗及び酸素濃度が重要であるが、説明の便宜上、管理が最も困難な酸素濃度についてのみ詳細な説明を行う。

【0025】ホストコンピュータ20には、各炉における過去の操業実績（操業条件及び酸素濃度分布等）が格納されている。狙い品種を製造するための各炉の操業条件が入力されると、コンピュータ10は、各炉ごとに、操業条件に対応する操業実績をホストコンピュータ20から受け入れてデータベースに格納する。次いで、その操業実績を用いて酸素濃度分布特性（酸素濃度分布推定用のテーブル）を作成し、作成した各炉の酸素濃度分布特性（酸素濃度分布推定用のテーブル）を用いて、育成される単結晶の軸方向の酸素濃度分布を推定する。

【0026】具体的には、品質実績データと引き上げ実績データとから、炉別・酸素スペック別にそれぞれ10バッチ分の酸素スペック、酸素実績、仕様部品サイズ、仕込み量を編集した中間データを生成する。中間データから、炉別・酸素スペック別に酸素実績データの平均値をとり、単結晶の軸方向に並べ代えて、テーブルデータとして登録する。登録された酸素濃度テーブルを運用し

て、酸素濃度分布を例えれば1mmごとに推定する。作成された酸素濃度テーブルの一例を表1に示し、そのテーブルから推定された酸素濃度分布を図4 (a) に示す。

【0027】

【表1】

L値	O _i 値	Min値	Max値
0	16.20	15.90	16.40
30	15.13	15.00	15.30
60	15.00	14.90	15.10
100	14.80	14.70	15.00
250	14.05	13.90	14.20
300	13.95	13.90	14.00
350	13.50	13.40	13.60
400	13.43	13.30	13.60
500	13.30	13.20	13.50
550	13.90	13.80	14.00
600	14.00	13.90	14.20
650	13.90	13.80	14.00
750	13.90	13.80	14.00
800	13.95	13.90	14.00
850	13.60	13.40	13.80
950	13.40	13.30	13.50
1000	13.30	13.20	13.40
1100	13.10	13.00	13.20
1150	13.00	12.90	13.10
1200	12.90	12.70	13.10

* 【0028】結晶生産システムでは、推定された内部品質分布と、決定された優先順位とを用いて製品の振り分けが行われる。

【0029】即ち、今、コンピュータ10に記憶されている製品の品質仕様を表2とし、推定された酸素濃度分布を図4 (a) とすると、振り分けは次のようにして実行される。

【0030】

【表2】

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優先順位	品種	酸素濃度 (atoms/cc)	製品化可能位置 (mm)	最終振分位置 (mm)
1	A	13.2~15.0	150~500	150~500
2	a	14.0~16.5	0~250	0~150
3	b	13.9~14.2	600~800	600~800
4	c	12.7~13.5	900~1200	900~1200
5	d	13.0~14.0	800~1150	800~900
6	e	12.7~15.0	50~1200	500~600

【0031】品種Aは所定の酸素濃度を指定された主品種(狙い品種)で、優先度の最も高いものである。品種

a, b, c, d・・・はそれぞれ所定の酸素濃度を指定された副品種で、主品種Aに比べて優先度が順に小さい

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ものである。

【0032】製品の振り分けでは、コンピュータ10は先ず、図4(b)に示すように、受注した製品の品質仕様(酸素濃度分布)と推定された酸素濃度範囲とから、単結晶において製品化が可能な範囲を決定する。狙い品種である品種Aは、単結晶のトップ近傍から中間部にかけて採取可能である。優先順位が第2位の品種aは、酸素濃度が高く、単結晶のトップ部から採取可能である。優先順位が第3、5位の品種b, dは、酸素濃度が比較的低く、単結晶の中間部からボトム近傍にかけて採取可能であり、特に品種bは酸素濃度のレンジが狭く品質仕様の厳しい品種である。優先順位が第4位の品種cは、酸素濃度が最も低く、単結晶のボトム部近傍から採取可能である。優先順位が第6位の品種eは、酸素濃度のレンジが広く、単結晶のほぼ全長から採取可能である。

【0033】製品化の可能な範囲が決定されると、図4(c-1)に示すように、受注量を考慮しつつ優先順位から製品の最終的な振り分けを行う。即ち、狙い品種である品種Aは、採取可能位置の全部に振り当てる。優先順位が第2位の品種aは、品種Aとの重複部分を避けて単結晶のトップ部に振り当てる。優先順位が第3位の品種bは、残りの部分に優先的に振り当てる。続けて、優先順位が第4、5、6位の品種c, d, eは、残りの部分に順に優先的に振り当てる。

【0034】品種eの受注量が多い場合は、図4(c-2)に示すように、品種cの一部を品種eに置き換える。また、品種dの受注量が多い場合は、図4(c-3)に示すように、品種cの一部を品種dに置き換える。

【0035】かくして、単結晶の全体から製品が受注状況に応じて余すことなく採取され、単結晶から製品を採取するときの歩留りが飛躍的に向上し、且つ受注に対する過不足も生じない。

【0036】加えて、各炉では品種Aを狙って単結晶を育成するものの、それらの酸素濃度分布は同じではないので、ある炉では採取できない製品も他の炉では採取できることになり、各炉で育成される単結晶に対して総合的な振り分けを行うことにより、実際の操業でも、受注に対する過不足を生じることなく、単結晶から製品が殆ど余すことなく採取される。

【0037】各炉で単結晶が育成されると、決定された振り分けに従って、単結晶を切断する。また、切断位置

で単結晶の酸素濃度を測定し、そのデータをコンピュータ10にフィードバックする。

【0038】各炉における酸素濃度分布特性(酸素濃度分布推定用のテーブル)は、厳密には1本の単結晶を育成するごとに変化する。このために、最新の実測データをコンピュータ10にフィードバックする。コンピュータ10は、常に最近の所定数のデータ(例えば最新から10個のデータ)を用いて酸素濃度分布特性(酸素濃度分布推定用のテーブル)を作成する。これにより、各炉で育成される単結晶の酸素濃度分布が高精度に推定される。

【0039】

【発明の効果】以上に説明した通り、本発明の結晶切断方法は、CZ法により単結晶を育成すると共に、育成される単結晶の軸方向の品質分布を過去の操業実績から推定し、推定された品質分布に基づいて、単結晶の切断位置を決定することにより、単結晶から製品を採取する際に、酸素濃度の要求スペックが異なる複数種類の製品を過不足なくダイレクトに切り出すことができるので、単結晶の酸素濃度を実測するための等長切断を必要とせず、切り戻しも必要としない。従って、製品採取の際の切断回数を大幅に低減でき、その切断での刃物コストを大幅に低減できる。また、切断に伴う薄厚品の派生を回避できるので、単結晶をウエーハに切断する際の工数を低減できる。

【図面の簡単な説明】

【図1】単結晶の比抵抗分布及び酸素濃度分布を模式的に示す図表である。

【図2】本発明の実施形態に係る結晶切断方法を用いた生産管理システムの装置構成図である。

【図3】同生産管理システムのソフトウェアを示すフローチャートである。

【図4】同生産管理システムにおける結晶切断方法の概念図である。

【図5】従来の結晶切断方法の概念図である。

【符号の説明】

10 コンピュータ

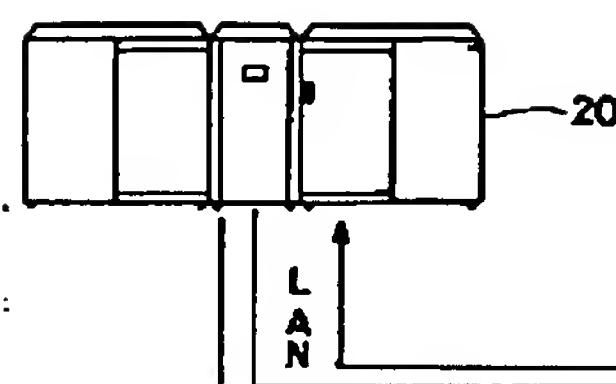
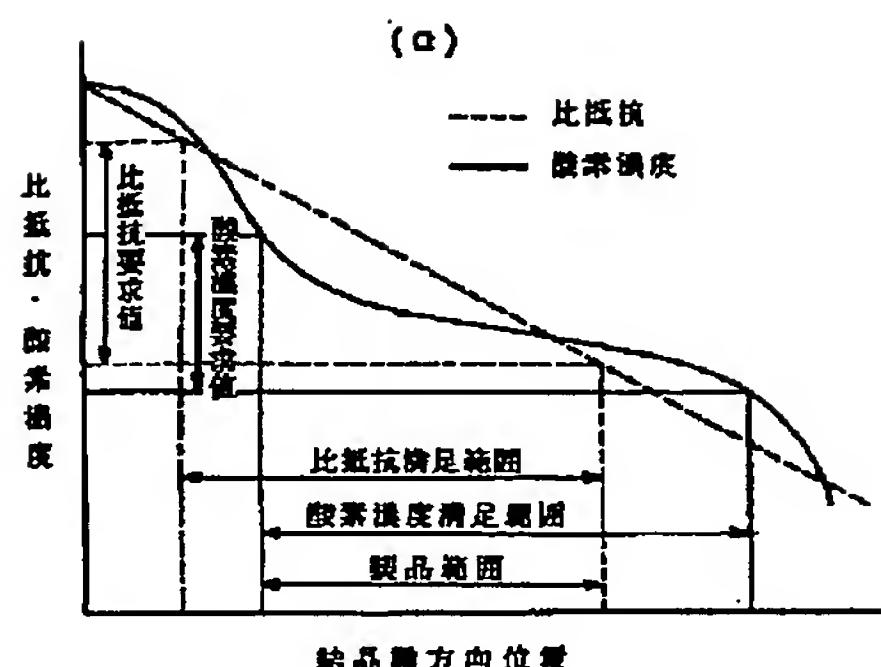
20 ホストコンピュータ

30 情報端末

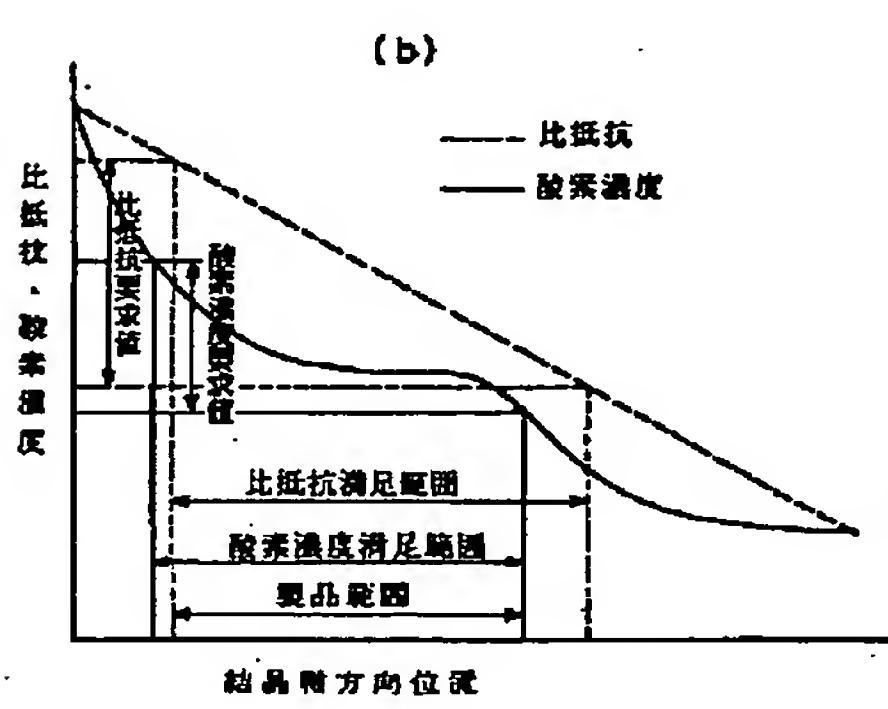
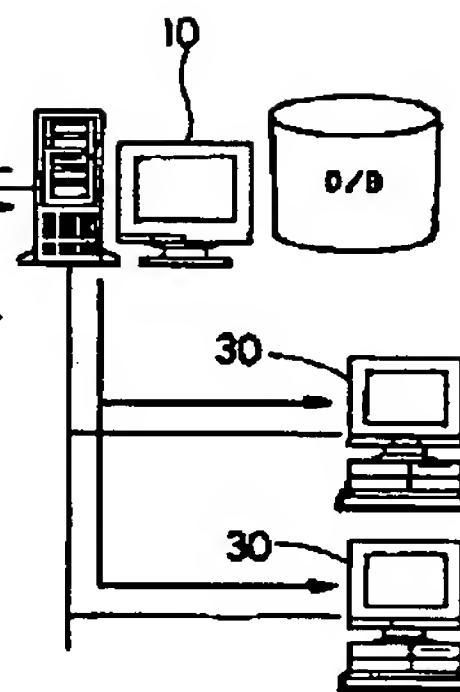
40 40 単結晶

41, 42... ブロック

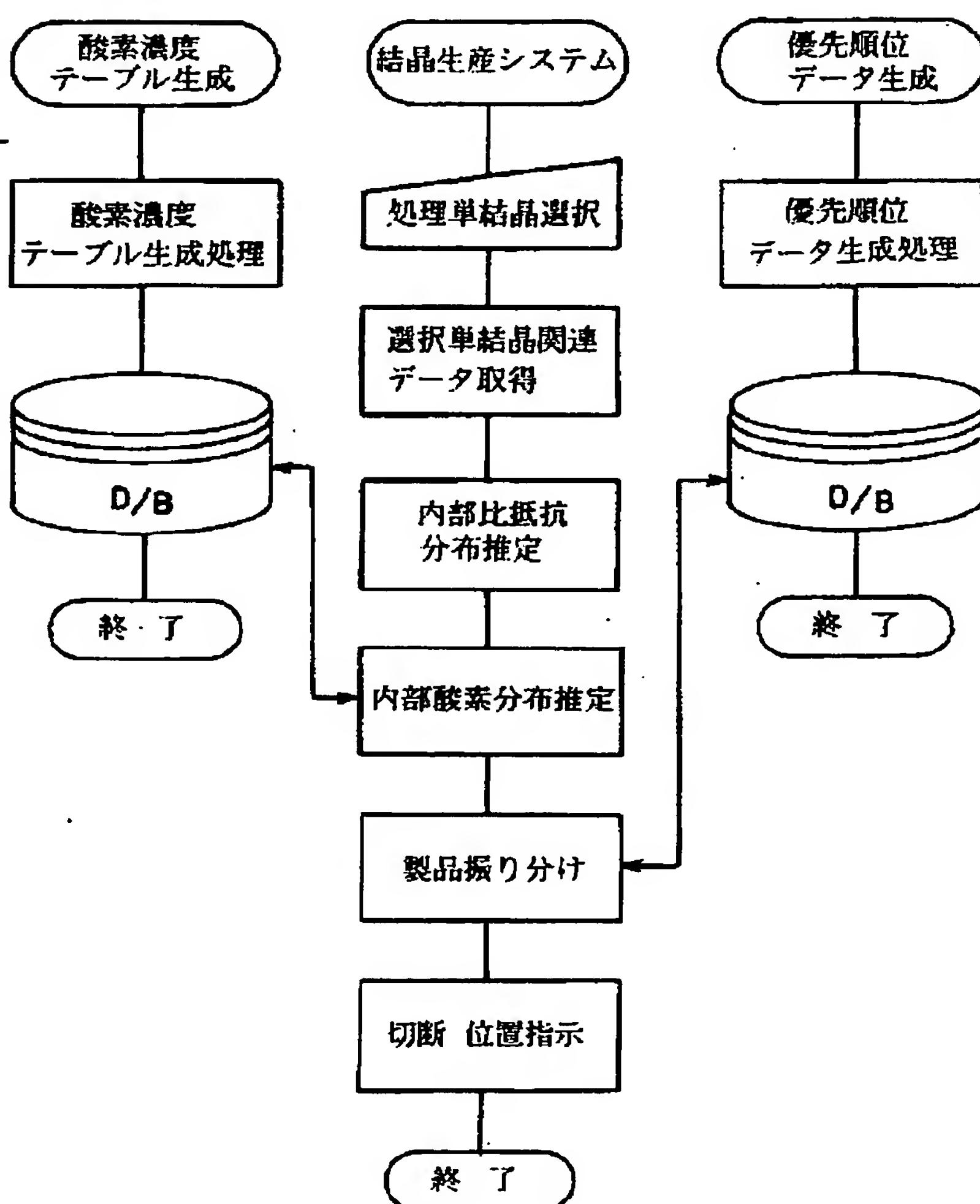
【図1】



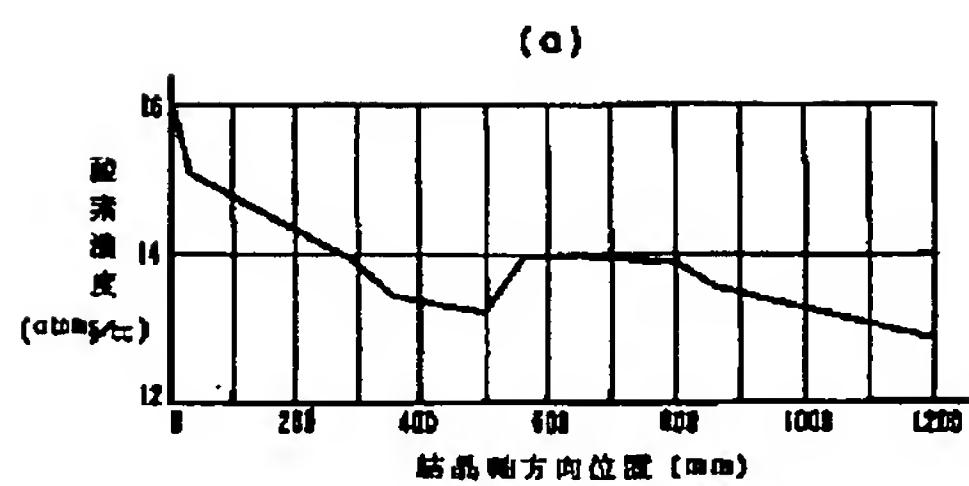
【図2】



【図3】



【図4】



【図5】

